and upper part of the roof may by degrees disappear until there is left only a narrow lower arch; and even this may waste away. Among the turtles the modifications in the temporal roof, numerous and extreme as they are, are not regarded as of great importance. It may be different, however, among the other reptiles. If so, then, as it appears to the writer, there might be five phyla of reptiles possessing in the temporal roof a single vacuity.

It is to be hoped that Dr. Williston's researches will lead to a solution of the difficult problem involved in the higher classification of the reptiles.

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FEDERLEY'S BREEDING EXPERIMENTS WITH THE MOTH PYGÆRA

Interesting results have recently been obtained by Federley[1] by breeding moths of the Notodontid genus *Pygœra*. Three common European species furnished the material—*P. curtula, P. pigra* and *P. anachoreta*.

The hybrids were not all equally easy to obtain. Numerous matings involving *P. anastomosis* were made, but no offspring were obtained. *Anachoreta* males show little inclination to pair with *curtula* females, but when such pairing occurs nearly all the eggs start developing, yet only a few reach the adult stage. On the other hand, the reciprocal mating (*curtula* male to *anachoreta* female) is easily accomplished, but produces only about 30 per cent. fertilized eggs. Of these most of the males and some of the females reach the adult stage. Thus it appears that "Paarungsaffinität" (tendency to mate), "sexuelle Affinität" (tendency toward fertilization) and "physiologische Affinität (tendency to produce fertile offspring) are independent.

One great difficulty met with was that the adult F_1 hybrids were very sterile. Only a single F_2 moth was raised, and only a few from the various back crosses (F_1 by P_1).

One of the characteristics of the species *anachoreta* is the presence of a white spot on the first abdominal segment of the caterpillar. In one of Federley's races of pure *anachoreta* there appeared, in the same brood, two caterpillars lacking the

[1] *Arch. Rass.- u. Gesellsch.-Biol.*, 8, 281, 1911. Reviewed also by M. Daiber, *Zts. ind. Abstamm.- u. Vererb.-Lehre.*, 6, 90, 1911.

spot. The mutation proved to be an ordinary Mendelian recessive. This spot is absent normally in *curtula,* and in crosses between *anachoreta* and *curtula* it does not appear in F_1, or at least is never of the full size. Its behavior in this hybrid is somewhat complicated, and more data will probably be required in order to explain it. But Federley's assumption of imperfect dominance of the same gene which behaves as a complete dominant in the *anachoreta* mutant seems hardly justifiable. The fact that the character behaves in the mutant as though due to a single factor does not mean that it must always so behave. It may depend upon the simultaneous presence or absence of several genes. If in the "spotless" mutant one of the required genes has dropped out, then the addition of that one to the complex will give the spot, and a case of Mendelian monohybridism will result. But *curtula* may be "spotless" because it lacks some other part of the required combination, in which case the behavior might be quite different from that in the case of the mutant.

When *curtula* and *pigra* were crossed, some of the F_1 imagos emerged after a pupal stage of about two weeks, while the rest hibernated as pupæ. The moths resulting from the two lots were quite different, the first (summer generation) being more similar to *curtula,* the second (spring generation) more like *pigra.* That this difference is not due to the effects of temperature is indicated by an F_2 moth reared from eggs laid by an individual of the summer generation. This moth hibernated in the pupal stage, yet resembled the summer generation. Furthermore, low temperature experiments on these *curtula-pigra* hybrids and upon *curtula-anachoreta* hybrids gave entirely negative results. Several facts bearing on this problem are given. Seasonal dimorphism is never a well-marked phenomenon in *Pygæra,* and does not seem to occur at all in the three species dealt with by Federley. From *pigra* he was unable to rear a summer generation. In the case of *curtula,* the Finnish races are univoltine, the German ones usually bivoltine. Crosses between the two latter did not give any consistent results.

The cross between *anachoreta* female and *curtula* male gives an F_1 brood which is sexually dimorphic. The males resemble their *anachoreta* mothers, and the females resemble the *curtula* father. From the reciprocal cross only males were reared. These also resembled *anachoreta.* However, Standfuss reared both

sexes but does not mention any dimorphism. Federley seems undecided as to whether this is a case of "spurious allelomorphism" (*i. e.,* sex-linkage) or a reversal of dominance due to a difference in sex (similar to the case of horns in sheep). But if, as he is inclined to suppose, Standfuss really got no dimorphism in his reciprocal cross, then this can not be a case of reversal of dominance, since if it were, reciprocal crosses would give the same results. It seems more probable that there is here a case of true sex-linked inheritance, the female being heterozygous for sex, as in *Abraxas.* Just what character is caused by the sex-linked gene is difficult to discover from Federley's account, but since this gene must be carried by *anachoreta,* let it be represented by *A.* The following formulæ, which I would suggest, in which *MM* denotes a male, *Mm* a female,[2] will then explain Federley's results:

curtula ♂ — *aM aM*
anachoreta ♀ — *AM am*
____
aM AM — ♂ similar to *anachoreta.*
aM am — ♀ similar to *curtula.*

anachoreta ♂ — *AM AM*
curtula ♀ — *aM am*
____
AM aM — ♂ similar to *anachoreta.*
AM am — ♀ similar to *anachoreta.*

The following back crosses were made:

F_1 ♂ — *AM aM*
curtula ♀ — *aM am*
____
AM aM — ♂ similar to *anachoreta.*
aM aM — ♂ similar to *curtula.*
AM am — ♀ similar to *anachoreta.*
aM am — ♀ similar to *curtula.*

This last mating produced only three males, which were very like the F_1 males. The next cross, and the expectation on the hypothesis of sex-linkage, is:

F_1 ♂ — *AM aM*
anachoreta ♀ — *AM am*
____
AM AM, *aM AM* } — ♂ similar to *anachoreta.*
AM am — ♀ similar to *anachoreta.*
aM am — ♀ similar to *curtula.*

[2] I have given my reasons for adopting this sex formula for birds and Lepidoptera in another paper (*Jour. Exp. Zool.,* 12, 499, 1912).

All the males from this cross were again similar to *anachoreta*, and there was apparently a fair number of them raised. All the females belonged to the *anachoreta* type, but they are said to have been few in number.

Thus, although the classes are not all filled, because of the small numbers obtained, the results of the back crosses are in agreement with the hypothesis that we have here a case of sex-linkage of the *Abraxas* type.

One interesting point is that in the cross of *curtula* male by *anachoreta* female, from which "hundreds" of females were raised, there occurred a single female resembling the males. This furnishes another case of partial sex-linkage, in addition to the one reported by Bateson and Punnett[3] and the others which I have analyzed in another paper.[4]

In practically all of Federley's cases the offspring of back crosses strongly resembled the hybrid parents, but he explains this as probably due largely to the great mortality of the caterpillars. In only a few cases were more than three or four offspring reared from such crosses. In two such back crosses there appeared caterpillars which had entirely new colors, presumably due to recombination, but unfortunately none of these survived until the imaginal stage.

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[3] *Jour. Genet.*, 1, 293, 1911.
[4] *Jour. Exp. Zool.*, 12, 499, 1912.